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PORTABLE ELECTRIC HEATER

FIELD OF THE INVENTION

This invention relates to a portable electric heater.

BACKGROUND OF THE INVENTION

A wide variety of portable electric heaters are currently available in different sizes, shapes, operation modes, etc. Some such heaters operate in one of three modes, i.e., a natural convection heating mode in which air typically flows through the heater with a natural convective flow, a forced convection heating mode in which air is forced through the heater by a fan, and a radiant heating mode in which a relatively large proportion of heat is output via radiation as opposed to convection or conduction. Forced convection mode heaters, sometimes called heater fans, may typically be made relatively small, yet operate with an external housing temperature below that required for safe operation. These heaters can have a relatively small housing and maintain a safe temperature because the air forced through the heater carries heat from the housing interior and keeps the heater relatively cool. One drawback to a forced convection heater is that the noise of the fan can be bothersome to people near the heater. A natural convection heater is typically quieter than a forced convection heater since no fan or other means to actively move air though the housing is used. However, natural convection heaters typically must have a larger volume than forced convection heaters of the same heat output to maintain a suitable exterior housing temperature. The larger volume may be needed for various reasons depending on the heater arrangement, e.g., to distance the heating element from the exterior housing surfaces, to induce convective airflow through the housing (so as to induce a chimney effect), to enable a larger heating element that operates at a lower heat output per unit area and/or has a lower operating temperature, and so on. The large size of such natural convection heaters can be a problem, in some cases, because of the large amount of space that they occupy.

SUMMARY OF THE INVENTION

In one aspect of the invention, a heater can operate in either a natural convection mode or a forced convection mode of heating. In the natural convection mode, the heater may maintain an exterior housing temperature below a threshold temperature, e.g., below an upper temperature limit for safer operation, and/or maintain an interior temperature

below an overheat limit while having a relatively small size, e.g., a volume of approximately 15,000 cubic centimeters (ccm). In one embodiment, the heater may have a rectangular box-like housing with a maximum height of about 25 cm, a maximum width of about 14 cm, and/or a maximum length of about 55 cm. In another embodiment, the heater may have a heat output of up to 1500 Watts.

In one illustrative embodiment of the invention, a portable heater includes a housing having an air inlet, an air outlet, an exterior surface and a front. A plurality of baffles are located within the housing along with a heating element capable of heating air flowing from the air inlet to the air outlet in a natural convection mode. The baffles are constructed and arranged to help maintain at least a portion of the exterior surface of the housing at or below a threshold temperature during heating in at least a natural convection mode and at least one of the baffles is positioned between the front of the housing and the heating element. In one embodiment, the threshold temperature may be about 150 or about 170 degrees Celsius.

In another illustrative embodiment, a portable heater includes a housing having an exterior surface, and a heating element positioned inside the housing and constructed and arranged to heat air. At least two substantially vertical baffles positioned inside the housing define an interior zone enclosing at least a portion of the heating element and define a secondary zone outside of the interior zone, but inside the housing. The at least two baffles, the housing and the heating element are arranged to operate in either a natural convection heating mode or a forced convection heating mode while maintaining the exterior surface of the housing below a threshold temperature.

In another illustrative embodiment, a portable heater includes a housing having an exterior surface, an air inlet and an air outlet. Both the air inlet and the air outlet may be less than about 25% of a surface area of the housing, and the housing may have a volume of less than about 18,000 ccm. A heating element may be located within the housing. The heater may be capable of sustained operation in a natural convection heating mode while maintaining the exterior surface of the housing below a threshold temperature of about 170 degrees Celsius.

In another illustrative embodiment, a portable heater includes a housing having an exterior surface, an air inlet, an air outlet and a total volume. An electric heating element is located within the housing such that the heater has a heat output of at least 750 Watts in a natural convection mode while maintaining the exterior surface of the housing

below a threshold temperature. A ratio of the heat output to the total volume of the housing is at least 0.082, and more preferably about 0.1. In other embodiments, the heater may have a heat output of about 1500 Watts, and the threshold temperature may be about 150 degrees Celsius.

These and other aspects of the present invention will be apparent from the following detailed description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Illustrative embodiments in accordance with aspects of the invention are described below in conjunction with the following drawings in which like numerals reference like elements and wherein:

Figure 1 is a right front perspective view of a heater in accordance with an aspect of the invention;

Figure 2 is left front perspective view of a heater shown in Figure 1;

Figure 3 is a bottom view of the heater shown in Figure 1;

Figure 4 is an exploded assembly view of the Figure 1 heater;

Figure 5 is a cross-sectional view taken along lines A-A as shown in Figure 1; and

Figure 6 is a cross-sectional view taken along lines B-B as shown in Figure 2.

DETAILED DESCRIPTION

Various embodiments in accordance with the invention may be used in a house, garage, office or similar environment to provide a primary heat source, or to supplement existing heat sources. For instance, the heater may be used in a garage where electricity is available, yet no other heating system exists. The heater may also be used to supplement an existing heating system in an indoor environment or in areas of a house that are difficult to heat, such as rooms with a lot of windows. Certain embodiments also have the benefit of a shallow profile that allows them to be located near a wall such that they do not take up much space in a room. The heater may also be sized to be portable, i.e., carried by hand and selectively placed within a space to be heated.

In one aspect of the invention, a portable heater 100, such as that shown in Figures 1 and 2, may have a relatively small size and operate in a natural convection mode, yet have a heat output of up to 750-1500 Watts. Achieving a relatively small

sized heater 100 with such a heat output in a natural convection mode is made difficult if the exterior surface of the heater housing remains below a relatively safer operating temperature, e.g., a temperature established by a testing laboratory or government agency, and/or a temperature that helps avoid burning or causing fire. The exterior surface of the heater housing is that portion of the heater housing normally exposed to human touch or contact with other objects that may be burned or otherwise heated. Thus, the exterior surface of the housing is not intended to include surfaces that are covered or otherwise arranged to prevent contact with objects outside the housing when the heater is in its normal configuration for heating. As discussed in detail below, in at least one aspect of the invention, the inventors have developed a heater that has the same heat output and operation parameters of some conventional natural convection heaters, but has a smaller sized housing.

Although a heater in accordance with various aspects of the invention may take any suitable form, in the illustrative embodiment shown in Figures 1 and 2, the heater 100 includes a housing 1 with a U-shaped bottom 10, a top grille 12 and two end plates 11 (shown in Figure 4). These components of the housing 1 may be made of sheet metal by a roll forming process, as is well known in the art, or any other suitable material, manufacturing method, or combination of different materials or methods. The heater 100 may also include endcaps 2 that cover the end plates 11 and support the heater 100, as well as carry a user interface 23 by which a user can control the operation of the heater 100. The end caps 2 in this embodiment are formed of a molded plastic material, but could alternatively be made of sheet metal, be a cast metal structure or have any other suitable construction. Further, the endcaps 2, like the housing 1, are not limited to the shape and/or size shown, but instead may have any suitable size, shape, appearance, etc. The user interface 23 may allow a user to choose whether to operate the heater in a natural convection mode, or a forced convection mode, allow selection of a wattage level or other heat output measure for the heater 100, allow setting of a desired thermostat temperature, allow adjustment of fan speed in the forced convection mode, or control of any other suitable heater parameters. In this embodiment, the user interface 23 includes a pair of control knobs that allow adjustment of a thermostatic control as well as the operation of a fan, but it should be appreciated that the user interface 23 may include any suitable input/display devices, such as switches, buttons, touch screens, temperature displays, and/or any other electric and/or mechanical devices.

In this illustrative embodiment, the heater 100 generally operates by heating air that enters the housing 1 via an air inlet 17 positioned on the bottom of the housing 1 (shown in Figure 3), and exhausting the heated air through an air outlet 18 near the top of the housing 1. Although the air inlet 17 and the air outlet 18 may take any suitable form, shape or size, in this embodiment the air inlet is formed by openings formed in the bottom of the U-shaped bottom 10 and the air outlet 18 is formed by openings in the top grille 12. In this embodiment, the air inlet 17 also includes an opening 17a formed in the front side of the U-shaped bottom 10 to allow air to pass into the housing 1 and help prevent false detection of overheat conditions in the housing 1, as will be discussed in more detail below.

In one aspect of the invention, a heater may have a heat output per unit volume of up to at least about 0.082 Watts/cubic centimeter (ccm), and more preferably up to at least about 0.1 Watts/ccm. For example, in the embodiment shown in Figure 1, the heater 100 has a housing 1 that has a total volume of less than about 18,000 ccm, preferably less than about 16,500 ccm, and more preferably less than about 15,100 ccm. The heater 100 in this embodiment has a heat output of up to at least 750 Watts, preferably up to at least 1300 Watts, and more preferably up to at least 1500 Watts. The heat output/unit volume may be up to at least about 0.082 Watts/ccm, and more preferably up to at least about 0.1 Watts/ccm. In this embodiment, the volume of the heater housing 1 is the volume enclosed by the U-shaped bottom 10, the top grille 12 and two end plates 11, but not the volume enclosed by the endcaps 2. That is, the endcaps 2 in this embodiment do not form a part of the housing 1, but rather serve to elevate the housing 1 above a floor or other support surface. Elevating the housing 1 allows the air inlet 17 to be placed on the bottom side of the housing 1 to draw in cold air near the floor, thus promoting natural convection. However, in embodiments where the endcaps 2 form part of the housing 1, the volume of the endcaps 2 may be included in the overall volume of the heater housing 1.

In another aspect of the invention, the housing 1 may have a total open area, or a total area of the perforated portions of the air inlet 17 and air outlet 18 for air movement, that is less than about 25% of the total surface area of the outer surface of the housing 1, and more preferably about 22% of the total surface area of the outer surface. In the Figure 1 embodiment, the total surface area of the outer surface of the housing 1 is about 4,617 square centimeters (sqcm), and is defined as the surface area of the U-shaped

bottom 10, the end plates 11 and the top grille 12 assuming no perforations or other air inlet/exhaust openings in any portion of the housing 1. In the Figure 1 embodiment, the bottom 10 has an area of about 2,762 sqcm, the endplates 11 each have an area of about 285 sqcm, and the grille 12 has an area of about 1,285 sqcm. The housing 1 in this embodiment has approximately 22% of this total surface area open such that air can pass. The total open area is the sum of the area of the perforated portions and any other openings for the air inlet 17 and air outlet 18, which in this embodiment is about 1000 sqcm, where the air inlet 17 has an open area of about 143 sqcm, and the air outlet 18 has an open area of about 860 sqcm.

Another aspect of the invention illustrated in the Figure 1 embodiment is that the heater 100 may have a maximum dimension of less than 70 cm, preferably less than 65 to 60 cm, and more preferably about 55 cm. For example, the bottom 10 and the top grille 12 have a length of approximately 55 cm. In addition, the heater 100 may have a second largest dimension of less than about 35 cm, preferably less than about 30 cm, and more preferably about 25 cm. That is, in one embodiment, the heater housing 1 may have a maximum length of about 55 cm and a maximum height of about 25 cm. The size and shape of the endcaps 2 is not a factor in determining the length and/or height of the housing 1 shown in the Figure 1 embodiment as these portions do not form a part of the housing 1. However, in other embodiments where endcaps 2 or similar structures form a part of the housing 1, the dimensions of the endcaps 2 may be included. The relatively compact size of the heater 100 shown in Figures 1 and 2, while having a heat output of 1300-1500 Watts, is typically not found in heaters in general, and portable heaters in particular, that operate in a natural convection heating mode. The reason is that without proper design of the heater components, at least some portions of the exterior surface of the housing 1 may tend to exceed a maximum threshold temperature, e.g., a temperature set by a government or quasi-government agency below which dangers of burning or other damage caused by heat at the exterior surface of the housing 1 may be minimized. For example, during operation of the heater, it is possible that a person may either inadvertently or intentionally contact the exterior surface of the heater housing. If the temperature level of exterior surface is kept below an acceptable threshold temperature, such as about 170 degrees Celsius, or more preferably about 150 degrees Celsius, severe burning or other injury, or burning of flammable substances may be avoided or mitigated. However, because of the arrangement of the heating element, housing and

other portions of the heater 100, the heater 100 may operate under normal conditions with a heat output of 1300-1500 Watts in a natural convection mode without causing the exterior surface to exceed a threshold temperature.

In another aspect of the invention, the heater may have one or more baffles located within the housing where at least one of the baffles is positioned between the heating element and a front of the housing. For example, Figure 4 shows an exploded assembly view of the heater 100. As shown, a pair of substantially vertical baffles 13 may be positioned in the housing 1 so that they extend from the floor of the bottom 10 upward toward the top grille 12. Although in this embodiment, the baffles 13 are shown as unperforated pieces of sheet metal, the baffles 13 may be made in any suitable way, e.g., have one or more openings, be made of materials other than metal, have one or more parts, etc. A heating element 14 may be positioned between the baffles 13, as shown in Figure 5, near the floor of the bottom 10. In this embodiment, the heating element 14 is mounted to a pair of brackets 19 that hold the heating element in place above the floor of the bottom 10, but any suitable arrangement may be used to mount the heating element 14. Although in this embodiment, one side of the heating element 14 extends beyond the baffles 13, the heating element 14 may extend beyond the baffles 13 on both sides, or be positioned within the baffles 13 so that the entire heating element 14 is shielded from the front and back portions of the U-shaped bottom 10. Thus, the vertical baffles 13 may define an interior zone within the housing 1 that at least partially encloses at least a portion of the heating element 14, e.g., so that at least a portion of one of the baffles 13 is positioned between at least a portion of the heating element 14 and either the front or back sides of the bottom 10. This may help reduce heat transfer from the heating element 14 to either the front or back sides by reflecting radiant heat, impeding air flow from the heating element 14 toward the front or back sides, and/or by other mechanisms. In turn, a secondary zone may be formed outside of the vertical baffles 13, yet inside of the housing 1, e.g., the secondary zone may include an area between the baffles 13 and the front and/or back sides of the bottom 10. The interior zone may be where heat is primarily transferred from the heating element 14 to air passing through the housing 1, while the secondary zone may help insulate at least portions of the exterior surface of the housing from the heat of the heating element 14. The baffles 13 may also help to direct the flow of air within the housing 1, e.g., to help induce a chimney-type effect that causes air to be drawn into the air inlet 17, heated by

the heating element 14, and exhausted through the air outlet 18 with or without the aid of a fan.

As discussed above, the heater 100 may operate in either natural convection or forced convection heating modes. In the forced convection mode, a fan 15 draws air from within the housing and exhausts the air through the top grille 12. The forced convection mode may be perceived as heating a space more quickly than the natural convection mode because heated air may be spread more quickly in the space by the fan 15. In this embodiment, the fan 15 generally draws air from inside the housing 1 along the length of the heater 100 above the heating element and then exhausts the heated air generally upwardly through the air outlet 18. It should be understood, however, that the fan 15 may draw and exhaust air in any suitable way and/or direction. The fan 15 may be any suitable type, such as an elongated axial fan, a centrifugal fan, etc., and may be controlled via the user interface 23. In this embodiment, the fan components located inside the housing 1 include a fan blade housing 151 and fan blade 152 that is driven by a fan motor 153 located on an opposite side of the end plate 11.

Safety may be a primary concern with electric heaters. For instance, without proper safety features employed in the heater 100, an article of clothing, paper, or other object that obstructs the air outlet 18 and/or inlet 17 may impede air movement in the housing 1 and cause an overheat condition as one or more portions of the exterior surface of the housing 1 becomes heated beyond a threshold temperature. This may, for example, potentially cause an object on the air outlet 18 to catch fire if proper safety features are not incorporated into the heater. Another safety consideration during normal operation of the heater is maintaining the exterior surface of the heater 100 at a suitable temperature, e.g., below a threshold temperature, to avoid burning people who touch the heater 100.

In one embodiment in accordance with the invention, the heater components, including the heating element, baffles, housing and/or other components may be arranged such that the heating element may operate at a maximum designed heat output, e.g., 1500 Watts, in a natural convection mode for an indefinite period without causing the temperature of the exterior surface of the housing to exceed a maximum threshold temperature, such as about 170 degrees Celsius, or more preferably about 150 degrees Celsius. Therefore, although possible in some embodiments, the power supplied to the heating element need not be controlled, e.g., as in a thermostatic or other similar control,

to maintain the exterior surface at or below an acceptable maximum temperature. Instead, the heating element may be supplied with power, e.g., at a 1500 Watt or other suitable level, for a sustained period under normal operating conditions and the temperature of the exterior surface of the housing will not exceed a threshold. This feature may allow the heater to output a maximum designed heat output, such as 1500 Watts, at a sustained level under normal operating conditions while operating in a natural convection mode and without causing an overheat condition of the housing. Normal operating conditions are those conditions normally expected while the heater is in use, i.e., the air inlet 17 and outlet 18 are not obstructed, the ambient air temperature is about room temperature, the heater is not tipped or tilted, etc.

Of course, various safety devices may also be employed to help assure that the temperature of the exterior surface does not exceed a threshold in the case of abnormal operating conditions, such as a partially obstructed air inlet or outlet, ambient air temperatures above normal room temperatures, a tipping or tilting of the housing 1, and so on. For example, at least one safety device 16, shown in Figures 5 and 6, may be placed inside the housing 1 to detect an overheat condition, and cause a reduction in power supplied to the heating element, i.e., power to the heating element may be interrupted or otherwise reduced if an overheat condition is detected. In this embodiment, the safety device 16 may be a resettable circuit breaker-type device that detects when the internal temperature of the housing 1 at a particular location exceeds a preset level, and in response reduces the heat output of the heating element 14. The safety device 16 may include a bi-metal strip, a thermistor, thermal fuse or any similar device that actively reduces power to the heating element, or may include a temperature sensor, e.g., a thermocouple, and associated control circuitry, relay, etc. to indirectly control power supplied to the heating element.

In this illustrative embodiment, the placement of the safety device 16 in the housing 1, as well as the size and position of the opening 17a, have been carefully designed to detect overheat conditions in the housing 1. An overheat condition is a condition that likely indicates the temperature of the housing exterior surface may exceed a threshold. Thus, the safety device 16 in this embodiment responds to a temperature in the housing that is an indirect, though usually accurate, indication of the temperature of a warmest portion of the exterior surface of the housing. The safety device 16 in this embodiment has also been arranged to detect overheat conditions while minimizing false

tripping, i.e., detecting an overheat condition when the exterior surface temperature has not, and/or likely will not, exceed the threshold. In this embodiment, the opening 17a supplies air from outside the housing 1 to a region near the safety device 16 so that the safety device 16 is less likely to false trip. Of course, the safety device 16 is not limited to the illustrated embodiment and may include one or more temperature sensors or other devices that actually detect the temperature at one or more portions of the exterior surface of the housing as well as, or instead of, detecting temperature inside the housing. The safety device 16 may override a thermostat, if present, that otherwise normally controls the power supplied to the heating element 14 to regulate the temperature in a heated space. Otherwise, the safety device 16 may be part of the thermostat or other control device and supply one or more temperature inputs used to control the heating element. The safety device 16 may also include backup, or secondary devices, such as a fuse, that reduces power to the heating element, e.g., if the current draw of the heating element exceeds a particular amperage or if the temperature in the housing exceeds a particular level.

In another aspect of the invention, the safety device 16 may be arranged so that it may respond to an overheat condition whether the heater is operating in a natural convection mode or a forced convection mode. Thus, two safety devices for each operation mode may not be necessary.

The geometry and location of the baffles 13, the heating element 14, the size and location of the air inlet 17 and air outlet 18, and the size and percent open area of the housing are all parameters which may determine whether the exterior surface of the housing 1 will be maintained within an acceptable temperature range while the heating element 14 operates for a sustained period. Balancing these parameters may be more difficult when the heater is configured to provide a relatively large amount of heat output for its size and to operate in both a natural convection mode and a forced convection mode. Figures 5 and 6 show dimensions for the various heater components in an illustrative embodiment. As shown in Figure 5, the heating element 14 has a length HEL of approximately 38 cm, which may be somewhat longer than the length BL of the baffles of approximately 35 cm. The length HEL of the heating element 14 in this case is the length of the heat exchanging portion of the element 14. Thus, the heating element 14 may have a supporting spine, plate or other structure as well as associated circuitry, etc. that is not included in the length HEL of the element 14. In the embodiment shown

in Figure 5, the heating element 14 has a supporting spine that is longer than the heat exchanging fins and supports the fins and electrical circuitry in the housing 1. In this embodiment, the heating element 14 extends beyond the baffles 13 on the right as shown in Figure 5, but is approximately aligned with the baffles 13 on the left. The safety device 16 in this embodiment may be positioned approximately 5.5 cm from the right end plate 11, and in this embodiment is supported by the heating element spine. The distance L between the end plates 11 is about 55 cm.

As shown in Figure 6, the housing 1 may have a maximum height H of approximately 25 cm, a maximum width W of about 13.5 cm, and have a substantially constant cross-sectional area along its length. The vertical baffles 13 may extend upwardly a height BH about 12.7 cm above the floor of the housing 1 in a substantially vertical direction. The baffles 13 are spaced a distance BW of approximately 7.5 cm apart from one another and a distance S approximately 2.0 cm from the front and rear wall of the housing, respectively. The top of heating element 14 may be situated within an interior zone defined by the baffles 13 at a height HEH of approximately 6.5 cm from the housing floor. The height HEX of the heat exchanging portion of the heating element 14 may be approximately 2.5 cm. The heating element 14 may be approximately centered between the baffles 13.

As discussed above, positioning of the safety device 16 may be important to the device's ability to accurately detect an overheat condition. To this end, the safety device 16 (or at least a temperature sensitive portion of the safety device 16) may be located upwardly a distance SDH of about 2.8 cm from the housing floor and approximately centered with respect to the front and back sides of the housing 1. The opening 17a may be centered in a longitudinal direction with respect to the safety device 16 so that appropriate venting is provided to prevent false tripping. Of course, the opening 17a may be eliminated or adjusted in size and location in other arrangements of the heater 100, e.g., where differently sized components are used.

In some cases, it may be desirable to prevent access to the heating element 14 and/or associated wiring from the air inlet 17, e.g., by preventing objects from being inserted through the air inlet 17 so as to contact the element 14. In one embodiment, a horizontal guard plate 20 may extend horizontally between the vertical baffles 13 at height of about 1.5 cm from the housing floor to prevent such access. The guard plate 20 may have openings to allow air to flow through the guard plate 20, but that are not

aligned with the openings for the air inlet 17. Thus, the openings for the air inlet 17 and the guard plate 20 may provide a labyrinthine path for air flow that prevents objects from being inserted into the housing 1 and contacting the heating element 14 or other components.

The particular shapes and sizes for the housing 1 components shown in Figures 1-6 have been found to be particularly effective in implementing various aspects of the invention, but other shapes and sizes for the housing are possible. For example, as can be seen in Figures 1-6, the top grille 12 has an inverted "W" shape, but other shaped top grilles may be used. Likewise, the U-shaped bottom 10 has a concave portion in the front side, but the concave portion is not necessary and the bottom 10 may have any suitable shape or size. In addition, the heater 100 shown in Figures 1-6 does not include any thermal insulation, but such insulation may be included in some embodiments, e.g., to reduce heating of some portions of the exterior surface of the housing.

While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the embodiments of the invention as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention.

What is claimed is: